

SYNTHETIC RESIN LAMINATE HAVING BOTH POLARIZATION  
CHARACTERISTIC AND PHOTOCHROMISM CHARACTERISTIC

## BACKGROUND OF THE INVENTION

### 1) Field of the Invention

The present invention relates to a synthetic resin laminate having both polarization characteristic and photochromism characteristic, and specifically to a synthetic resin laminate having good appearance and excellent optical characteristics which is used for glare-reducing materials such as goggle and sun glass for sport use and can be readily produced and processed.

### 2) Prior Art

Goggles and sun glasses for sport use which have polarization characteristic exhibit excellent cutting characteristic against a reflected light. Thus, their usefulness in outdoor activities such as marine sport, skiing and fishing has come to be noticed widely. Recently, their demand has suddenly expanded. Particularly, when a polycarbonate resin is used for their material, the tendency is remarkable since it exhibits excellent impact resistance.

On the other hand, with rapid development of excellent photochromic pigment, the characteristic of

photochromic sun glasses to change transmittance depending upon surrounding brightness also has remarkably been improved, so that they also have been rapidly enhancing popularity.

Ideas concerning a synthetic resin glare-reducing material having both a function to change transmittance depending on surrounding brightness and a function to block preferentially a reflected light have been suggested. However, in the present situation, they have not been put into practice yet, because even if a concrete constitution of a glare-reducing material with required properties was suggested, a concrete process for production thereof was practically poor or properties of a product thus obtained were insufficient in the present production process.

For example, in the production of a polycarbonate lens described in Japanese Patent Publication No.7-94154, when a process comprising adding a photochromic pigment in the production of a polycarbonate sheet to be used is applied, a lens thus obtained is insufficient in both response speed and contrast. Also in resins other than a polycarbonate, a sheet with strength usable as a glare-reducing material usually causes problems that degradation of a photochromic pigment occurs during kneading; the

kneading is troublesome and contrast or response speed of a product thus obtained is small.

In a process comprising coating a surface layer of a polarizing lens to be obtained in the process described in Japanese Patent Publication No.7-94154 with a photochromic pigment-containing resin, it is difficult to form a lens with good contrast since the thickness of an applicable coating layer is limited.

#### SUMMARY OF THE INVENTION

The present invention is to provide a synthetic resin laminate for a glare-reducing material having both polarization characteristic and photochromism characteristic which can be readily processed.

As a result of extensive trials and studies for various methods, the inventors have found that a laminate interposed a resin layer having photochromism characteristic and a resin layer having polarization characteristic between two transparent synthetic resins exhibits not only excellent both photochromism characteristic and polarization characteristic, but also processing into curved surfaces and injection molding can be readily performed and the laminate can be produced in a very simple process, and have accomplished

the present invention.

That is, the present invention provides a synthetic resin laminate having both photochromism characteristic and polarization characteristic consisting essentially of two transparent synthetic resin layers, a resin layer having photochromism characteristic and a resin layer having polarization characteristic interposed between said two transparent synthetic resin layers and an adhesive layer to adhere said resin layer having polarization characteristic to said one transparent synthetic resin layer, wherein said one transparent synthetic resin layer to contact said resin layer having photochromism characteristic has a thickness of 50  $\mu\text{m}$  or above and a retardation value of 150 nm or below, or 3000 nm or above.

It is preferable that said one transparent synthetic resin to contact said adhesive layer has a thickness of 100  $\mu\text{m}$  or above.

It is preferable that said transparent synthetic resin is a polycarbonate resin. Also resins excellent in impact resistance, transparency and strength other than a polycarbonate resin can be used.

Further, it is preferable that said resin layer having photochromism characteristic is an urethane resin layer containing a photochromic pigment(s).

It is preferable that said resin layer having polarization characteristic is a polarizing film.

#### BRIEF DESCRIPTION OF THE DRAWING

Figure 1 is a cross sectional view of the synthetic resin laminate in the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

The present invention will be described in detail using Figure 1.

In Figure 1, (A) shows a transparent synthetic resin layer (hereinafter, " (A)" ); (B) shows a resin layer having photochromism characteristic (hereinafter, " (B)" ); (C) shows a resin layer having polarization characteristic (hereinafter, " (C)" ); (D) shows an adhesive layer (hereinafter, " (D)" ) and (E) shows a transparent synthetic resin layer (hereinafter, " (E)" ).

When the synthetic resin laminate of the present invention is used as a glare-reducing material such as a sun glass and a sporting goggle, the side of (A) (hereinafter, " (A) side" ) is used as outside and the side of (E) (hereinafter, " (E) side" ) is used as inside. For example, a user of a sun glass applied the synthetic resin laminate of the present invention sees objects from (E) side of the sun glass lens of inside

through (A) side of the outside.

When the synthetic resin laminate is processed into curved surfaces, it is processed so as to form a concave shape in (A) side and a convex shape in (E) side. Further, when other resin is adhered to the synthetic resin laminate by injection molding, etc., notwithstanding a flat sheet or an article processed into curved surfaces, the other resin with low UV absorption and transparency may be adhered to (A) side or (E) side of the laminate. According to the said other resin added to UV absorption or pigment, it is preferable that the said other resin is adhered to (A) side.

When the components, concentration and thickness of (A), (B), (C), (D) and (E) are combined as described later, the synthetic resin laminate exhibits excellent optical characteristics and it becomes possible to perform its processing into curved surfaces and injection molding.

Each layer in the synthetic resin laminate is described in detail below.

It is preferable that (A) has a thickness of 50  $\mu\text{m}$  or above and a retardation value (hereinafter, "Re" ) of 150 nm or below, or 3000 nm or above and substantially, (A) is a sheet to transmit a light with a

wave length of 350 nm or above.

In the present invention, Re (nm) of the synthetic resin layer is defined in the following formula.

$$\text{Retardation value (Re) (nm)} = \Delta n \times d$$

wherein  $\Delta n$  is a birefringence of the synthetic resin layer and d is a thickness (nm) of the synthetic resin layer.

When the synthetic resin laminate is used as a glare-reducing material outside the above-mentioned range of Re, it is not preferable since colored interference figure is generated.

When a polycarbonate resin is used as (A), it is required that it has a thickness of 50 to 200  $\mu\text{m}$  and Re of 150 nm or below or a thickness of 300  $\mu\text{m}$  to 1 mm and Re of 3000 nm or above. Outside the above-mentioned range, the following some problems occur.

(1) When the synthetic resin laminate is processed into curved surfaces, interference figure is observed.

(2) The synthetic resin laminate does not possess satisfactory strength.

(3) A processed article with good appearance



cannot be obtained.

(4) Polarization characteristic is deteriorated in an injection molding.

(5) It is not practical since it is difficult to obtain a raw material.

The polycarbonate resin sheet having the above-mentioned range of Re in the present invention can be produced, for example, by the following process.

That is, the sheet having Re of 150 nm or below can be produced by a casting process or a non-stretching extrusion process. The sheet having Re of 3000 nm or above can be produced by changing a polycarbonate resin to a sheet by an extrusion process and then stretching substantially the sheet in one direction while heating to a somewhat higher temperature (e.g., about 140 to about 180 °C) than glass transition temperature. In such case, stretching magnification exerts an influence on Re.

It is preferable that (B) is an urethane resin layer containing a photochromic pigment(s) and (B) has a thickness of 50 to 250  $\mu\text{m}$ . When the thickness is below 50  $\mu\text{m}$ , color development is insufficient under irradiation of an ultraviolet light and contrast becomes low. When the thickness is above 250  $\mu\text{m}$ , contrast is sufficient, but economy becomes bad since a large amount

of high price photochromic pigment is used.

The photochromic pigment is not limited on the condition that it has compatibility with the urethane resin layer. Spiropyran compounds, spiroxazine compounds and naphthopyran compounds are preferable.

Examples of the spiropyran compound include 1',3',3'-trimethylspiro(2H-1-benzopyran-2,2'-indoline), 1',3',3'-trimethylspiro-8-nitro(2H-1-benzopyran-2,2'-indoline), 1',3',3'-trimethyl-6-hydroxyspiro(2H-1-benzopyran-2,2'-indoline), 1',3',3'-trimethylspiro-8-methoxy(2H-1-benzopyran-2,2'-indoline), 5'-chloro-1',3',3'-trimethyl-6-nitrospiro(2H-1-benzopyran-2,2'-indoline), 6,8-dibromo-1',3',3'-trimethylspiro(2H-1-benzopyran-2,2'-indoline), 8-ethoxy-1',3',3',4',7'-pentamethylspiro(2H-1-benzopyran-2,2'-indoline), 5'-chloro-1',3',3'-trimethylspiro-6,8-dinitro(2H-1-benzopyran-2,2'-indoline), 3,3,1-diphenyl-3H-naphtho(2,1-b)pyran, 1,3,3-triphenylspiro[indoline-2,3'-(3H)-naphtho(2,1-b)pyran], 1-(2,3,4,5,6-pentamethylbenzyl)-3,3-dimethylspiro[indoline-2,3'-(3H)-naphtho(2,1-b)pyran], 1-(2-methoxy-5-nitrobenzyl)-3,3-dimethylspiro[indoline-2,3'-naphtho(2,1-b)pyran], 1-(2-nitrobenzyl)-3,3-dimethylspiro[indoline-2,3'-naphtho(2,1-b)pyran], 1-(2-naphthylmethyl)-3,3-dimethylspiro[indoline-2,3'-naphtho(2,1-b)pyran] and 1,3,3-

trimethyl-6'-nitro-spiro [2H-1-benzopyran-2,2'-[2H]-indole].

Examples of the spiroxazine compound include 1,3,3-trimethylspiro [indolino-2,3'-[3H] naphth [2,1-b] [1,4] oxazine], 5-methoxy-1,3,3-trimethylspiro [indolino-2,3'-[3H] naphth [2,1-b] [1,4] oxazine], 5-chloro-1,3,3-trimethylspiro [indolino-2,3'-[3H] naphth [2,1-b] [1,4] oxazine], 4,7-diethoxy-1,3,3-trimethylspiro [indolino-2,3'-[3H] naphth [2,1-b] [1,4] oxazine], 5-chloro-1-butyl-3,3-dimethylspiro [indolino-2,3'-[3H] naphth [2,1-b] [1,4] oxazine], 1,3,3,5-tetramethyl-9'-ethoxyspiro [indolino-2,3'-[3H] naphth [2,1-b] [1,4] oxazine], 1-benzyl-3,3-dimethylspiro [indoline-2,3'-[3H] naphth [2,1-b] [1,4] oxazine], 1-(4-methoxybenzyl)-3,3-dimethylspiro [indoline-2,3'-[3H] naphth [2,1-b] [1,4] oxazine], 1-(2-methylbenzyl)-3,3-dimethylspiro [indoline-2,3'-[3H] naphth [2,1-b] [1,4] oxazine], 1-(3,5-dimethylbenzyl)-3,3-dimethylspiro [indoline-2,3'-[3H] naphth [2,1-b] [1,4] oxazine], 1-(4-chlorobenzyl)-3,3-dimethylspiro [indoline-2,3'-[3H] naphth [2,1-b] [1,4] oxazine], 1-(4-bromobenzyl)-3,3-dimethylspiro [indoline-2,3'-[3H] naphth [2,1-b] [1,4] oxazine], 1-(2-fluorobenzyl)-3,3-dimethylspiro [indoline-2,3'-[3H] naphth [2,1-b] [1,4] oxazine], 1,3,5,6-tetramethyl-3-ethylspiro [indoline-2,3'-[3H]

pyrido [3,2-f] [1,4]-benzoxazine], 1,3,3,5,6-pentamethylspiro [indoline-2,3'-[3H] pyrido [3,2-f] [1,4]-benzoxazine], 6'-(2,3-dihydro-1H-indole-1-yl)-1,3-dihydro-3,3-dimethyl-1-propyl-spiro [2H-indole-2,3'-[3H] naphth [2,1-b] [1,4] oxazine], 6'-(2,3-dihydro-1H-indole-1-yl)-1,3-dihydro-3,3-dimethyl-1-(2-methylpropyl)-spiro [2H-indole-2,3'-[3H]- naphth [2,1-b] [1,4] oxazine], 1,3,3-trimethyl-1-6'-(2,3-dihydro-1H-indole-1-yl)-spiro [2H-indole-2,3'-[3H]- naphth [2,1-b] [1,4] oxazine], 1,3,3-trimethyl-6'-(1-piperidinyl)-spiro [2H-indole-2,3'-[3H]- naphth [2,1-b] [1,4] oxazine], 1,3,3-trimethyl-6'-(1-piperidinyl)-spiro [2H-indole-2,3'-[3H]-naphth [2,1-b] [1,4] oxazine], 1,3,3-trimethyl-6'-(1-piperidinyl)-6-(trifluoromethyl)-spiro [2H-indole-2,3'-[3H]- naphth [2,1-b] [1,4] oxazine] and 1,3,3,5,6-pentamethyl-spiro [2H-indole-2,3'-[3H] naphth [2,1-b] [1,4] oxazine].

Examples of the naphthopyran compound include 3,3-diphenyl-3H-naphtho [2,1-b] pyran, 2,2-diphenyl-2H-naphtho [1,2-b] pyran, 3-(2-fluorophenyl)-3-(4-methoxyphenyl)-3H-naphtho [2,1-b] pyran, 3-(2-methyl-4-methoxyphenyl)-3-(4-ethoxyphenyl)-3H-naphtho [2,1-b] pyran, 3-(2-furil)-3-(2-fluorophenyl)-3H-naphtho [2,1-b] pyran, 3-(2-thienyl)-3-(2-fluoro-4-methoxyphenyl)-3H-naphtho [2,1-b] pyran, 3-{2-(1-methylpyrrolidinyl)}-3-

(2-methyl-4-methoxyphenyl)-3H-naphtho [2,1-b] pyran, spiro [bicyclo [3.3.1] nonane-9,3'-3H-naphtho [2,1-b] pyran], spiro [bicyclo [3.3.1] nonane-9-2'-3H-naphtho [2,1-b] pyran], 4-[4-[6-(4-morpholynyl)-3-phenyl-3H-naphtho [2,1-b] pyran-3-yl] phenyl]-morpholine, 4-[3-(4-methoxyphenyl)-3-phenyl-3H-naphtho [2,1-b] pyran-6-yl]-morpholine, 4-[3,3-bis(4-methoxyphenyl)-3H-naphtho [2,1-b] pyran-6-yl]-morpholine, 4-[3-phenyl-3-[4-(1-piperidinyl) phenyl]-3H-naphtho [2,1-b] pyran-6-yl]-morpholine and 2,2-diphenyl-2H-naphtho [2,1-b] pyran.

As processes for forming the urethane resin layer containing a photochromic pigment(s), the following various processes can be applied.

(1) A process comprising dissolving a polyurethane resin and a photochromic pigments(s) in a solvent, coating a solution thus obtained on (A) or (C), then evaporating the solvent and then adhering the urethane resin layer to (C) or (A) with heating.

(2) A process comprising heat melt adhering a polyurethane resin kneaded a photochromic pigments(s) to a transparent resin sheet so as to form a uniform thickness.

(3) A process comprising coating a resin solution dissolved a photochromic pigment(s) and a curing agent in a polyurethane prepolymer on (A) or (C),

then evaporating a solvent (in case of containing a solvent), then adhering the urethane resin layer to (A) or (C) and then performing cure.

Although all of the above-mentioned processes can be applied in principle, it is preferable that a two-liquid type polyurethane containing a polyurethane prepolymer and a curing agent is used, considering productivity and necessary apparatus.

As the polyurethane prepolymer, a compound reacted isocyanate and polyol in a specific proportion is used. That is, the polyurethane prepolymer is a compound with an isocyanate group on both ends to be obtained from diisocyanate and polyol. It is preferable that the diisocyanate compound to be used for the polyurethane prepolymer is diphenylmethane-4,4'-diisocyanate (MDI). It is preferable that the polyol is polypropylene glycol (PPG) having a polymerization degree of 5 to 30.

The polyurethane prepolymer has a number average molecular weight of 500 to 5000, preferably 1500 to 4000 and more preferably 2000 to 3000.

The curing agent is not limited on the condition that it is a compound having two or above hydroxyl groups. Examples of the curing agent include polyurethane polyol, polyether polyol, polyester polyol,

acrylic polyol, polybutadiene polyol and polycarbonate polyol. Among them, polyurethane polyol having a hydroxy group on its end to be obtained from specific isocyanate and specific polyol is preferable, and particularly it is preferable to use polyurethane polyol having a hydroxy group on at least both ends to be derived from diisocyanate and polyol. It is preferable that said diisocyanate is tolylene-diisocyanate (TDI) and said polyol is PPG having a polymerization degree of 5 to 30.

The curing agent has a number average molecular weight of 500 to 5000, preferably 1500 to 4000 and more preferably 2000 to 3000.

The ratio of isocyanate group (I) of the polyurethane prepolymer to hydroxyl group (H) of the curing agent of 0.9 to 20 and preferably 1 to 10 may be preferably applied as a standard.

Solvents such as ethyl acetate, tetrahydrofuran and toluene may be applied to the polyurethane prepolymer and the curing agent in order to adjust viscosity.

(C) may be basically any polarizing film. It is preferable that (C) has a comparatively high transmittance of 30 % or above and a thickness of 10 to 100  $\mu\text{m}$ . When the thickness is below 10  $\mu\text{m}$ , strength becomes low and it is difficult to obtain intended

polarization characteristic. When the thickness is above 100  $\mu\text{m}$ , it is difficult to obtain uniformity of the thickness and ununiformity of color often occurs. An iodine type polarizing film is not so preferable and a dye type polarizing film is preferable, considering processing with heating such as injection molding.

Particularly, as described in Japanese Patent Kokai (Laid-open) No.63-311203, a film with high heat resistance produced by a process of production comprising performing particular treatment for a film with a metal ion(s) and boric acid to stabilize the film is preferable. Further, it is very preferable to use a polarizing film with UV cutting characteristic.

(D) may be any adhesive on the condition that conventional polycarbonate resin can be adhered to a polarizing film. A polyurethane resin to be used in the resin layer having photochromism characteristic of above-mentioned (B) is usually applied as the adhesive. Particularly, it is preferable to apply a two-liquid type polyurethane containing a polyurethane prepolymer and a curing agent, considering post processing. The range of thickness of (D) is preferably 5 to 100  $\mu\text{m}$  and more preferably 5 to 50  $\mu\text{m}$ . When the thickness is below 5  $\mu\text{m}$ , it is difficult to obtain sufficient adhesive force. When the thickness is above 100  $\mu\text{m}$ , the adhesive



force is sufficient, but the long time is required to evaporate a solvent in the adhesive, so that productivity and economy becomes bad. It is possible to provide UV cutting potency for the laminate by adding a UV absorber to (D).

When the synthetic resin laminate is used in an injection molding, it is necessary that (E) has a thickness of 100  $\mu\text{m}$  or above. When the thickness is below 100  $\mu\text{m}$ , lines and crack are often generated. Further, it is necessary to select the thickness of (E) so as to make total thickness of the synthetic resin laminate 0.6 mm or above from the aspect of strength and quality except that afterwards its thickness is increased by a process such as injection molding.

Particularly, a preferable process for producing the synthetic resin laminate of the present invention is as follows.

That is, a resin solution containing a photochromic pigment(s), a polyurethane prepolymer and a curing agent is coated on a polarizing film and then standing at a temperature of 20 to 50  $^{\circ}\text{C}$  for about 5 to 60 minutes. Then, a transparent synthetic resin sheet (A) is adhered to the resin solution layer. An adhesive containing a solvent is coated on the side of the polarizing film of the laminate thus obtained and then

standing for about 5 to 60 minutes at a temperature of 20 to 50 °C and the solvent is evaporated. Then, another transparent synthetic resin layer (E) is adhered to the adhesive. The laminate thus obtained is heat cured usually at a temperature of 60 to 140 °C over 2 hours to one week, whereby the synthetic resin laminate of the present invention is produced.

#### PREFERRED EMBODIMENTS OF THE INVENTION

The present invention will be described in more detail below, referring to examples which are not intended to limit the scope of the present invention.

Each properties was measured by the following methods.

##### [Transmittance]

The measurement was performed with a spectrophotometer, manufactured by Nihon Bunko k.k., in Japan.

[Single sheet transmittance, paralalled position transmittance and perpendicularly crossing position transmittance]

Single sheet Transmittance, parallel position transmittance ( $H_0$ : light transmittance where the same

species of two polarizing films or two sheets to each other are overlapped so as to pose orientation direction toward the same direction to each other) and perpendicularly crossing position transmittance ( $H_{90}$ : light transmittance where the same species of two polarizing films or two sheets to each other are overlapped so as to pose orientation direction toward a direction perpendicular to each other) are an average value made visible sensitivity amendment in a visible radiation of 400 to 700nm.

[Polarization degree]

Polarization degree was determined from the following formula

$$H(\%) = \sqrt{\frac{H_0 - H_{90}}{H_0 + H_{90}}} \times 100(\%)$$

[Retardation value(Re)]

The measurement was performed with a polarizing microscope, manufactured by Oak Seisakusho, in Japan, TEM-120AFT.

[Transmittance under irradiation of ultraviolet light]

A single wave length light of 360 nm was

irradiated with a monochromatic light source and transmittance was measured after 5 minutes from the starting of the irradiation.

#### Example 1

(1) Preparation of photochromic pigment-containing resin solution.

15 g of a polyurethane prepolymer having a NCO group equivalent weight (equivalent weight: average molecular weight per one functional group) of 1500 prepared from diphenylmethane-4,4'-diisocyanate (MDI) and polypropylene glycol (PPG) having an average polymerization degree of 15, 3 g of a curing agent having a hydroxyl group equivalent weight of 1050 prepared from tolylenediisocyanate and polypropylene glycol having an average polymerization degree of 10, 0.25 g of a photochromic pigment ① [3,3-diphenyl-3H-naphtho (2,1-b) pyran], 0.08 g of a photochromic pigment ② [spiro (2H-indole-2,3'-(3H)-naphtho (2,1-b) (1,4) oxazine)-1,3-dihydro-1,3,3-trimethyl-6'-(1-piperidinyl)], 0.18 g of a hindered amine compound [bis(2,2,6,6-tetramethyl-4-piperidinyl) sebacate] and 12 g of tetrahydrofuran were uniformly mixed.

(2) Preparation of polarizing film

A polyvinyl alcohol film, manufactured by Kurare k.k., in Japan, trade name; Kurarevinylone #7500 was dyed at 35 °C for 6 minutes in an aqueous solution (dyeing solution) containing 0.37 g/L of Chlorantin fast red (C.I. (color index generic name): Direct Red 81), 0.28 g/L of Brilliant blue 6B (C.I.: Direct Blue 1), 0.28 g/L of Direct copper blue 2B (C.I. :Direct Blue 168), 0.93 g/L of Primuler blue 6 GL (C.I.: Direct Blue 202) and 0.28 g/L of Chrysophenine (C.I.: Direct Yellow 12) and then stretched 5 times in the dyeing solution to the direction of uniaxis.

Then, the above-mentioned film was immersed in an aqueous solution (treating solution) containing 0.30 g/L of nickel acetate tetrahydrate and 12.2 g of boric acid at a room temperature for 3 minutes in the state maintained stretching. Further, the film was taken out from the aqueous solution in the state maintained the tension and water washed and dried, and then subjected to heat treatment at 110 °C for 7 minutes.

The polarizing film thus obtained presented light grey and had a thickness of 30 µm and its optical characteristics were single sheet transmittance: 41.8 % and polarization degree: 96.3 %.

### (3) Preparation of resin solution for adhesive

layer

15 g of above-mentioned polyurethane prepolymer, 3 g of above-mentioned curing agent and 27 g of ethyl acetate were uniformly mixed.

#### (4) Production of laminate

The resin solution obtained by the process of above-mentioned (1) was coated with a doctor blade of coating thickness 300  $\mu\text{m}$ , manufactured by Yoshimitsu Seiki k.k., in Japan on the polarizing film obtained in above-mentioned (2), and then standing for 10 minutes in the atmosphere of 45  $^{\circ}\text{C}$ . Then, the surface coated with the resin liquid was adhered to a polycarbonate film of thickness 120  $\mu\text{m}$  and Re 60 nm. The thickness of the laminate was 313  $\mu\text{m}$  by measurement with a micrometer. It was found that the thickness of the resin layer having photochromism characteristic was 163  $\mu\text{m}$ .

Then, an urethane adhesive was coated with a bar coater #24 on the side of the polarizing film in the laminate so as to form a thickness of 10  $\mu\text{m}$  after evaporation of the solvent and a solvent was vaporized and then a polycarbonate sheet of thickness 300  $\mu\text{m}$  was adhered thereto.

The laminate thus obtained was heat cured at 70  $^{\circ}\text{C}$  for 2 days. The total thickness of the laminate

thus obtained was 620  $\mu\text{m}$ .

When a light was not irradiated on the laminate, the transmittance was 41.9 % and the polarization degree was 96.2 %. Thus, the optical characteristics of the laminate were the same as those of the polarizing film. The color of the non-irradiated laminate was light grey.

On the other hand, when a sun light was irradiated on the laminate, the color of the laminate was changed to deep brown within 10 seconds. It was found that when the irradiation was stopped, the color reverted to original light grey in a short time of about 10 seconds.

The single sheet transmittance was 24.5 % and the polarization degree was 96.4 % during irradiation of an ultraviolet light. The visual observation result under a sun light was numerically confirmed. The appearance of the laminate was very good.

#### Example 2

The laminate sheet obtained in Example 1 was cut into a size of 80 mm  $\phi$  and then aspirated up to 50 mmHg for 1 minute simultaneously with starting of heating in the atmosphere of 147  $^{\circ}\text{C}$  and vacuum molded for 6 minutes to process into a lens of curvature radius

80 mm.

The appearance of the article obtained by processing into curved surfaces was very good and no interference figure thereof was observed. The optical characteristics of the processed article were the same as those prior to processing in both cases of light irradiation and non-irradiation.

### Example 3

In order to adhere the sheet subjected to processing into curved surfaces obtained in Example 2 to a molded article with an injection molder of clamping force 150 ton, it was in advance installed in a mold of a set temperature 110 °C with cavity of the curved form. An aromatic polycarbonate resin (trade name: IUPILON H-4000, manufactured by Mitsubish Gas Chemical Co., Inc.) put in a hot wind drier at 120 °C for 6 hours or above sufficient to satisfy the mold cavity in a molder cylinder of set temperature 260 °C was weighed. The molten polycarbonate resin was injection charged in the cavity of the closed molder installed the sheet subjected to processing into curved surfaces and then maintained for 30 seconds under a retention pressure of 700 kg/cm<sup>2</sup> and then the molded article was cool solidified in the mold for 120 seconds. Then, the mold



was opened and the molded article was taken out from the mold.

The surface of molded article thus obtained was adhered to the sheet subjected to processing into curved surfaces in advance installed. The molded article with good appearance was obtained. The molded article possesses both polarization characteristic and photochromism characteristic and its strain was small.

#### Example 4

(1) Preparation of photochromic pigment-containing resin solution.

The preparation was performed in the same manner as in Example 1 except that the photochromic pigments were changed to 0.17 g of Reversacol Flame, manufactured by James Robinson Co.

(2) Preparation of polarizing film

The preparation was performed in the same manner as in Example 1.

(3) Production of laminate

A laminate of both sides thickness 600  $\mu$ m and total thickness about 1.4 mm was obtained in the same manner as in Example 1 by using two polycarbonate sheets

of thickness 600  $\mu\text{m}$  and Re 4000 nm.

The laminate presented deep orange under the irradiation of a sun light and light grey under the non-irradiation of a light. The transmittance was 42.1 % and the polarization degree was 95.7 %.

The laminate was cut into a shape of length 40 mm and width 200 mm and then subjected to processing into curved surfaces to form a spherical surface with curvature radius 85 mm under the conditions according to Example 2.

The color and brightness of the article subjected to processing into curved surfaces were the same as those prior to processing in both cases of irradiation and non-irradiation of a sun light.

Its appearance was very good without observing skewness and no interference figure was observed. Thus, it was judged that it was suitable to skiing goggle.

#### Comparative Example 1

The laminate was produced in the same manner as in Example 1 except that Re of the polycarbonate film corresponding to (A) was changed from 60 nm to 1500 nm. The thickness of the laminate thus obtained was 622  $\mu\text{m}$ . The laminate was subjected to processing into curved surfaces to make a lens. When a reflected light was seen

through the lens, an interference figure was observed.

#### Comparative Example 2

The laminate was produced in the same manner as in Example 1 except that the resin solution obtained in (1) was coated on the polarizing film obtained in (2) and then the surface coated with the resin solution was adhered to a polycarbonate sheet of thickness 300  $\mu\text{m}$  and Re 1000 nm and then a urethane adhesive was coated on the side of the polarizing film in the laminate and adhered to a polycarbonate film of thickness 120  $\mu\text{m}$  and Re 60 nm. The thickness of the laminate thus obtained was 614  $\mu\text{m}$ .

A sun light was irradiated on the side of the polycarbonate film of thickness 120  $\mu\text{m}$  and Re 60 nm in the laminate. The laminate was changed to somewhat brownish color, but so remarkable color development as in Example 1 was not observed. The transmittance under irradiation of an ultraviolet light from the same direction as that of a sun light was about 36 %.

#### Comparative Example 3

The laminate was produced in the same manner as in Example 1 except that the resin solution was prepared without adding the photochromic pigment ① and

the photochromic pigment ②. The thickness of the laminate thus obtained was 618  $\mu\text{m}$ . When the laminate was exposed to a sun light, no color development was observed and both transmittance and polarization degree in non-irradiation of an ultraviolet were the same as those in the case of non-irradiation of a light in Example 1. Glare reduction was not attained so much as in the laminate produced in Example 1 to develop color under irradiation of an ultraviolet light.

#### Comparative Example 4

The photochromic pigment-containing resin solution was prepared in the same manner as in Example 1. The resin solution was coated on a polycarbonate sheet of thickness 300  $\mu\text{m}$ , with a doctor blade of thickness 300  $\mu\text{m}$ , manufactured by Yoshimitsu Seiki k.k., in Japan and then standing for 10 minutes in the atmosphere of 45  $^{\circ}\text{C}$ . Then, the surface coated with the resin solution was adhered to a polycarbonate film of thickness 120  $\mu\text{m}$  and Re 60 nm. The thickness of the laminate thus obtained was 578  $\mu\text{m}$  and the thickness of the photochromic resin layer was 158  $\mu\text{m}$  by measurement with a micrometer. Then, the laminate was heat cured for 2 days at 70  $^{\circ}\text{C}$ . Total thickness of the laminate thus obtained was 575  $\mu\text{m}$ .

The transmittance of the laminate in non-irradiation of an ultraviolet light was 83 % and the transmittance under irradiation of an ultraviolet light was 64 %. The laminate has no polarization characteristic and glare-reduction was not attained so much as the laminate of Example 1.

The synthetic resin laminate of the present invention, having both polarization characteristic and photochromism characteristic is suitably applicable to the use of glare-reducing materials such as sporting goggle and sun glass and a synthetic resin sun glass with magnification can be readily produced by the combination with an injection molding.